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Gaining Order from Chaos: Will Automation Do It?

A Monograph
by

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GAINING ORDER FROM CHAOS~~; SHOULD WE~~ WILL AUTOMATION DO IT?

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B2C2

ATCCS
M1A2 TANK

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ABSTRACT

GAINING ORDER FROM CHAOS: WILL AUTOMATION DO IT? by MAJ Joseph A. Moore, USA, 44 pages.

The purpose of this monograph is to determine whether the Army's proposed tactical automation system as defined by the battalion and below command and control (B^2C^2) program will support current command and control (C^2) doctrine or lead to a more prescriptive doctrine. The Army is on the verge of a profound improvement in tactical automation. The current systems, represented by the maneuver control system (MCS), are large, unwieldy machines located in command posts and requiring manual input of all data. Future systems, such as the developmental intervehicular information system (IVIS) on M1A2 tanks, are fundamentally different. IVIS is integral to every combat system and capable of automatically or manually entering information. The graphic display of this information greatly improves the leader's view of the battlefield.

Historical analysis of command and control methods determined four C^2 options with utility for modern commanders; minimal control, directive control, forward positioning, and detailed control. Historically, C^2 systems varied from centralized to decentralized control regardless of the technology available. An analysis of current US Army doctrine reveals a preference for directive control and forward positioning of the commander by stressing his ability to see the battlefield.

The tenets of Army operations are the foundation of current US Army doctrine. An analysis of the proposed automation systems with respect to the five tenets indicates that all five tenets were significantly improved. More importantly, automation appears to support decentralization of tactical decisions because of the information's timeliness and utility, ease of coordination, enhanced decision making, and improved ability to visualize the battle.

The study concludes that future automation supports current command and control doctrine in most cases. The information provided by B^2C^2 will materially improve the tactical leader's ability to see the battle, but lacks the detail required to centralize decisions at a higher level. Only in situations where time is plentiful or the task unfamiliar to the unit will automation support centralized control.

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I. INTRODUCTION

> Two questions [concerning automation and communication] have arisen: What is the effect of the new devices on existing methods, and how can the devices best be put to use?[1]

As Martin van Creveld noted above, attempts to improve the command and control (C^2) of armies are not new. Technological solutions to overcome command and control challenges became common after the telegraph and, more importantly, the radio made their debut on the battlefield. Today, the emergence of powerful, portable computers linked to sophisticated communications may open a new opportunity to vastly improve C^2.

The US Army is in the midst of an expensive and controversial effort to automate its command and control systems, extending from the strategic to tactical levels. While the programs for improving strategic and operational C^2 are generally accepted as necessary, the programs for tactical C^2 are not universally applauded.

The cost of the proposed modernization lies at the heart of the issue. GEN (R) Paul Gorman once observed that the Army, unlike the other services, consists of tens of thousands of parts on the battlefield. In battle, it is an order of magnitude more complex than the Air Force and orders of magnitude larger than the Navy.[2] Automating this colossal organization will be expensive and has many critics among the Army's senior leadership.

Military journals are full of articles calling for caution in the automation of the Army's tactical command and control systems. GEN (R) John Foss, former CG, TRADOC, and LTG (R) Leonard P. Wishart III, former CG,

CAC, among others, have cautioned of automation's inevitable use as a tool to overly control tactical units.[3] An additional concern of many critics is that the centralized approach will not work in a modern battle environment and is therefore dangerous for the dependency it may create.[4] This argument was particularly relevant when the US Army faced a large and sophisticated enemy, such as the former Soviet Union. However, today the Army is focused on smaller, less sophisticated regional threats.[5] Many possible foes have capable and lethal military forces, but they will not likely have the capability to broadly disrupt tactical communications.

The relevant issue appears to be that automation, when it works, leads to excessive control by whatever headquarters receives the information.[6] The concern about the impact of a heavily automated C^2 systems on the Army's tactical command and control doctrine is valid. An automated C^2 system might lead to prescriptive control of tactical units by centralizing decisions at a higher headquarters, or it may merely improve the current C^2 system available to tactical commanders. The purpose of this monograph is to examine this issue.

History provides excellent examples of command and control systems potentially useful to modern armies. One might surmise that command and control of ancient armies was very different from that practiced today. Actually, the C^2 of these armies have striking similarities to contemporary approaches. Generally, command and control methods range from very centralized prescriptive control to decentralized directive control, and on occasion to little, if any, control. An examination of these

historical approaches to command and control provides an insight into the challenges, and perhaps solutions, for contemporary armies.

II. HISTORICAL ANALYSIS

Ancient Greek armies tended to be relatively large masses of citizen soldiers. Greek society could not afford the luxury of a standing army. Instead it required its citizens to fight for the community and each citizen provided his own equipment. Seldom were specialized units, such as cavalry, available in quantity. The armies, while composed of subunits, were unitary in nature; they were not divided into self-sufficient units. In a Greek phalanx, each unit fought as its neighbors did without separate missions. Additionally, the size and shape of the army was very limited and determined before combat.[7]

Some Greek communities elected prominent citizens to command its troops once war was imminent. These leaders seldom performed military service between wars, though many were experienced warriors due to the near continuous state of warfare in early Greek civilization. The function of early leaders primarily consisted of choosing the place for battle, the particular formation for the fight, and command of the decisive wing in battle. Subordinate leaders executed the commander's plan and, like their general, fought at the front of their units. Seldom were messengers or signals successfully used to adjust the plan of battle.[8]

Battle consisted of a rush to close combat between opposing masses. The emphasis was placed on shock. The

goal was to break the opponent's formation and destroy him before he could reconstitute an effective formation.[9] The short duration of actual combat limited the leader's opportunity to control the fight to any significant degree. The forward positioning of leaders at the decisive point in a "do as I do" role and the use of as few subordinate units as possible simplified the Greek Army's control problem.[10]

By 100 B.C., Rome introduced the western world to a large, standing army. Professional soldiers, experienced in war and peacetime training, provided superb leadership to the army. These professional soldiers developed a considerably more complex organization of subordinate units that surpassed the Greek phalanx as a viable tactical formation.[11] Ten cohorts of six hundred men each formed a Roman legion, with each cohort having its own commander, standard and bugler. The cohorts were formed in a checkerboard pattern that allowed tactical leaders to see the action on his flanks and have room for maneuver.[12]

Unlike the Greeks, senior Roman leaders tended to hang back from actual combat, roaming freely throughout the battlefield. Specialized units and reserves were committed to the fight by these commanders. The Romans developed signals to control their army while the commanders positioned themselves at the decisive point of the battle. However, their efforts were to control the action, not to lead their men into combat.[13]

Experienced, professional soldiers provided strong leadership at the tactical level in the Roman army. These leaders remained with their legion throughout their career, in peace and war. The legion's leadership was

expected to exercise initiative during the battle if the circumstances required it.[14] This gave them significant flexibility at the lowest tactical echelons.

Additionally, the professional Roman army introduced standard procedures and drills for battle. This allowed it to perform intricate maneuvers during battle and to execute movements quickly.[15] These two factors, drills and initiative among tactical leaders, combined with the more flexible formation made the Roman army the most feared in the western world for centuries.[16]

The collapse of the Roman empire brought on a resurgence of the unitary army structure used by the Greek army. During medieval times many armies were composed of mounted heavy cavalry supported by infantry and other auxiliaries. These armies were not the standing professional armies of the Romans. Instead, they were small bands of free knights with a loose affiliation to their monarch.[17] As in ancient warfare, the initial charge often determined the victor in battle. To withstand a cavalry charge, the infantry had to form huge massed squares. These unwieldy squares were very similar to the Greek phalanx. Not surprisingly, this similarity to the ancient Greek methods of war extended to command and control as well.

Heroic, personal leadership during battle was the standard for the noble leaders of these armies. With few aides to assist him, a leader's control over the army in battle seldom extended beyond the range of his voice. Until well into the seventeenth century, this method of command provided leadership but seldom provided control over the army.[18]

By the thirteenth century, the archer, equipped with the much improved longbow, contributed to the demise of the massed cavalry charge.[19] The development of firepower slowly changed the character of war. The mass of mounted knights and infantry provided an easy target for the archers, and later musketeers. Gradually, infantry, armed with muskets, became the primary component of the army.

The army's formation changed to increase the firepower of the infantry and reduce the effects of the enemy's weapons. The massed square became a temporary expedient when attacked by cavalry, while the normal formation was the battalion on line with eight to ten ranks. Now the army could occupy miles of countryside instead of a few acres. The army's increase in numbers, size, and complexity greatly complicated command and control. However, by late in the seventeenth century, command and control of armies would significantly change with the senior leaders moving to the rear of the army to control the battle.[20]

By the Thirty Years War, generals could no longer see the entire army.[21] Gustavus Adolphus, like many commanders, followed the Hellenistic tradition of placing himself with the decisive wing where he fought the battle much as Greek commanders did. Other commanders, such as Marlborough and Wellington, used the mobility of the horse to move throughout the battlefield and influence events at many points in their armies.[22] However, regardless of the technique, each was able to influence only one portion of their army at a time, though aides extended their control to any unit within their sight.

In the eighteenth century, Frederick the Great demonstrated an exceptional command and control system for the unitary army. Frederick developed an army of incredible discipline. The army's entire organization and training was designed to execute the orders of its commander. Frederick "attempted continuous control of the whole army, and relying for this purpose on as robot-like body of troops as has ever been put into the field."[23] His use of centralized, prescriptive control depended on the iron discipline of his soldiers, enforced by the ruthless measures of his officers and sergeants; the strict obedience of subordinate leaders; and the practiced drills of his army.[24] Frederick's success also depended on his genius for tactical and strategic decisions. When the battle was fought as expected, the Prussian Army could win spectacular victories, but on many occasions it performed less brilliantly. In the hands of less capable commanders imitating his style of C^2, the results often produced disasters.[25]

The emergence of Napoleon's *grande armee*, commonly more than one hundred thousand men, ended the era of the unitary army. It did not maneuver as a single mass, but was distributed over hundreds of kilometers while on the march, and tens of kilometers when in battle. To deal with such an army, Napoleon organized an efficient staff, an army of self-contained, mission oriented corps, and a method of collecting information on his enemy and friendly dispositions.[26]

Previously, unitary armies fought as a single coherent block under the watchful eye of its commander (the Romans and Frederick) or personally led into the fight (the

Greeks and Gustavus). However, Napoleon's distributed army operated with individual missions and axes of advance for each corps. While Napoleon personally directed the operational and strategic maneuvers of his army, he left nearly all of the tactical control of his corps and lower level formations to subordinates.[27] Instead, Napoleon coordinated the efforts of his corps through an elaborate staff.

Napoleon's staff was more sophisticated than anything previously attempted. Three components made up the staff; the maison, the general staff, and the administrative staff, which dealt with the logistics of the army and Napoleon's entourage.[28] The general staff was the primary means of communication between Napoleon and his corps. The general staff handled routine information such as strength and position reporting. However, its most important function was to translate Napoleon's instructions into more detailed directives for the corps commanders to execute.[29] This was a significant improvement over previous staffs.

Meanwhile, the various aides within the maison provided what Martin van Creveld termed the "directed telescopes."[30] These aides carried critical orders during battle, observed key dispositions of the corps, gathered intelligence on the enemy, and generally observed any part of the battle Napoleon desired.[31] This greatly accelerated the flow of reliable information to Napoleon. In this manner, he could usually control elements of his army beyond the range of his personal view.

While operational control of Napoleon's army was undergoing a profound change, tactical control of his

battalions was similar to that in armies of previous centuries. Commanders of battalions through divisions controlled a relatively small, highly concentrated formation of a single type. They had the same tools for control as a centurion in a Roman legion such as flags, bugles and messengers. Personal leadership during battle was the norm.[32] Also like the centurion, the commander in Napoleon's army was responsible for drilling his unit for battle and for using personal initiative within the framework of the battle. But, tactical command and control was on the verge of significant change for the first time in centuries.

The advent of the rifle, machinegun, and quick firing cannon dramatically increased the amount of firepower on the battlefield. The days of the battalion formed into columns for the attack were disappearing. Early forms of firepower extended the length of the army as the number of ranks steadily decreased from eight to ten in 1600 to three in Napoleon's army.[33] Yet, soldiers within the battalion remained shoulder to shoulder throughout the period. By 1860, with the advent of the lethal, rifled musket, individual soldiers could not remain so closely formed. Changes in the command and control of armies to deal with the dispersed formation were inevitable.

The Prussian, and later the German army, introduced *auftragstaktik*, or mission order control of both tactical and operational forces. Operationally, Helmuth von Moltke refined Napoleon's use of the general staff, both as a directed telescope and a coordinating and planning staff. Unlike Napoleon, von Moltke's headquarters remained well to the rear to coordinate the movements of his huge army

since the telegraph gave the Prussians a tool for commanding forces over great distances. Unfortunately, the telegraph did not provide the technological means to control such large forces over vast spaces. It was too slow to transmit large volumes of information and too cumbersome to move with the army.[34]

Therefore, von Moltke did not maintain centralized control of his armies, instead he chose to direct their actions toward an operational objective. His plans were flexible enough, and his armies strong enough, to handle local reverses and still maintain the strategic initiative.[35] Like Napoleon, von Moltke found it impossible to control the details of the tactical employment of his armies.

Possibly for the first time, controlling the details of employing a combat battalion proved as difficult as the control of the armies. The Prussian solution to the confusion of the dispersed tactical battle was to empower the company commander with great flexibility in battle. They believed the company commander was the key to controlling the soldiers of the newly-dispersed formations.[36] Since communications improvements did not extend to this level, it meant the tactical leaders could not be controlled from the rear.

Instead the Prussians developed mission oriented leaders. In the absence of guidance, each subordinate was expected to follow the intent of his mission once battlefield conditions forced changes in the original plan. Initiative was expected, if not demanded, of company and battalion leaders. The attitude was that it was better for subordinates to disobey a superior's order

if the action met the superior's intent than to lose an opportunity for decisive action by waiting on his decision during battle.[37] Limited control by their superiors was possible by personally supervising the unit at the expected *schwerpunkt*, or the main effort. Sometimes this was done by directed telescopes, such as Ludendorff's efforts in World War I.[38] Some leaders, such as Rommel and other panzer leaders of World War II, personally supervised the main effort.[39]

During World War I, the British solution to the command and control dilemma was to use a variant of Frederick's prescriptive control. The High Command planned intricate schedules of barrage fires to support the infantry attacks. This early attempt at synchronization failed to meet the demands of the day. Seldom could the infantry keep pace with the artillery's creeping barrage.[40] Worse yet, the British High Command was unaware of their problem in synchronizing the two forces until after the battle.

Telephones provided a reliable means of communication from army headquarters to battalion command posts in the trenches, but it did not extend beyond the trenches during attacks. Therefore, battalion commanders were forbidden to leave their command posts to accompany their troops in the attack since communication, and presumably control, would end.[41] This represented the first time that technology constrained tactical leadership in an effort to improve control of the army.

The British Army's problem of control ending at the "end of the wire" has been the challenge of the modern era. While the telephone was the sole means used to

communicate between headquarters, and could not extend beyond the trenches, the tactical commander's dilemma was whether to remain in the command post and communicate with his superiors or lead his men into battle.[42] Needless to say, the higher headquarters received incomplete and misleading information from its tactical commanders. Worse, the battalions lacked the experience and personal leadership of their commanders. The British Army adopted Frederick's centralized, prescriptive control, but lacked the necessary capability to control its infantry formations and Frederick's ability to see the battle and adjust the plan accordingly.

Many critics of technology have accused improvements in C^2 systems of supporting the tendency toward centralized control.[43] Today, computer and modern communication means tend to draw tactical commanders to their command posts as telephone communications did the British at the Somme. While radios provide commanders at all levels with communications, regardless of their location, radios are insufficient for the vast quantities of information a modern army generates.[44] The maneuver control system (MCS) hardware, mobile subscriber equipment (MSE), and numerous other automated information systems and devices tend to be located in command posts. These systems provide commanders with a wealth of information and assist planning process. If the battalion commander chooses to remain in his command post to have access to this information, his subordinates operate without his personal leadership and guidance. The commander's only link to his forces in combat becomes the radio.

Radios give the tactical commander access to his subordinates and staff, but he is limited to their descriptions of the battle unless he is positioned forward. When forward, modern optics have extended the range of his vision, but they have not kept pace with the extension of the unit. The modern battalion may extend five or more kilometers in breadth and up to twice that in depth. Additionally, other units supporting the battalion may be kilometers from the commander's location. This means the commander faces the problem of where to position himself on the battlefield. Modern company and battalion commanders can see only a fraction of the unit's battle, yet are expected to control the entire fight.

To overcome the C^2 dilemma, the modern battalion commander's choices are nearly the same as for his predecessors in earlier armies. P actically, he has four options as identified by Brigadier Richard E. Simpkin in his work <u>Human Factors in Mechanized Warfare</u>: minimal control; directive, or mission order control; forward command; and detailed order control.[15]

First, the tactical commander can relinquish control as the ancient Greek and medieval leaders did and assume a "follow me" approach. Many historical examples demonstrate this technique. Modern warfare does not seem to lend itself to this technique because of its multitude of specialized units integrating their efforts across a large and lethal battlefield.

Second, directive control, or *auftragstaktik*, trusts subordinates to carry out the intent of the plan and make correct decisions as the situation changes. Simpkin's analysis of directive control requires the superior to provide the subordinate with his overall intention for the operation, the task the subordinate must accomplish, the resources he can expect, and any constraints on how he does it.[46]

Third, a leader can choose to lead from the decisive point and influence the action there, trusting his staff and subordinates to keep him informed of activities elsewhere. Alternatively, he can take advantage of modern mobility to move about the battlefield, much as Marlborough, Frederick, and Rommel, to control as many subordinates as possible.

Lastly, a commander can prescribe all of his subordinate's actions much like a chessmaster would during a game of chess. This approach usually worked for Frederick, but seldom for his imitators. On the modern battlefield, prescriptive, or detailed order control requires the higher commander to have significant electronic support to display and communicate information, to issue extremely detailed orders in advance of the battle, and possess comprehensive SOP's for subordinate unit actions.[47]

These command and control techniques are not mutually exclusive. However, they do resemble a sliding scale based on centralization. Detailed control represents the most centralized approach while minimal control is the most decentralized. Directive control would appear somewhat toward the center, while forward positioning implies general decentralization except for the unit at the main effort.[48] Given these historical approaches to command and control and modern alternatives for leading units in combat, an analysis of the current US Army doctrine for C^2 is appropriate to determine how the US Army intends to command its tactical forces in modern warfare.

III. DOCTRINAL ANALYSIS

The US Army's current doctrine for command and control, as described in FM 100-5 Operations, describes techniques closely related to the German Army's concept of *auftragstaktik*, alternately called mission orders (freedom of action) in FM 101-5 (Coordinating Draft) and directive control by Brigauier Simpkin.[49] The newest editions of FM 100-5 (Preliminary Draft) and FM 101-5 further refine the technique by emphasizing that commanders should focus on what a subordinate must do without prescribing how it is to be done.[50] According to FM 100-5, commanding is the process of directing and motivating subordinates and their

units toward accomplishing a mission. Its components are leadership and decisions.[51] The purpose of most improvements in C^2 systems is to improve the commander's decisions making, but they must not interfere with the commander's leadership responsibilities.

FM 100-5 describes control as defining limits for subordinates. Its purpose is to calculate requirements, allocate resources, and integrate the efforts of a commander's subordinates and staff.[52] Additionally, "control serves its purpose if it allows the commander freedom to operate, delegate authority, lead from any critical point on the battlefield, and to synchronize actions across his entire area of operation."[53]

FM 101-5 simply states that control is the "process by which commanders employ or direct combat power of assigned and supporting units."[54] It also describes how he does this. FM 101-5 defines two methods of control, procedural and positive. **Procedural control** is the indirect control of a unit. It consists of regulations, standard procedures, policies, the operations order's mission statement, the commander's intent statement, and the concept and graphic control measures. **Positive control** is more direct. It is the dynamic, personal process of a commander adjusting the actions of his subordinates over time. It is particularly common in vague or complex situations. Fragmentary orders, choosing a contingency

plan, shifting the main effort, and modifying the actions of the unit during a battle are examples of positive control.[55]

FM 101-5 also warns of the dangers of the two methods. Procedural control works well when the tasks and situation are clear and the tasks conform to prescribed actions. However, it is not a reliable predictor of the correct actions for all situations. Additionally, procedural control may stifle subordinate initiative by emphasis on strict compliance.[56] Detailed orders that prescribe the subordinate's every action should be avoided. Instead mission orders that grant considerable freedom of action to subordinates are the foundation of the Army's procedural control.[57]

Positive control tends to require extraordinary amounts of information and reliable communication. The demands placed on the commander and staff that exert positive control are significant in fast-moving situations. Like procedural control, excessive positive control may erode subordinate initiative as they come to rely on their superior's decisions.[58]

Additionally, doctrinal guidance provides commanders great flexibility in their own positioning. Specifically, the "C^2 system must permit tactical leaders to position themselves wherever they can best command without depriving them of the ability to respond to opportunities

and changing circumstances."[59] FM 100-5 also stresses the importance of personal leadership of subordinates and requires the tactical commander to "be where he can best influence the battle, where his moral and physical presence can be felt."[60] The emphasis for leaders of tactical formations is to position so as to best see the battle and influence subordinates.

In summary, US Army C^2 doctrine calls for commanders to plan operations that maximize their subordinates' freedom of action through the use of mission orders. During operations the commander has great latitude in positioning, though there is a strong bias toward forward positioning in tactical units. Regardless of his location, the commander must be capable of receiving timely information and analyzing the situation. He must see the battlefield, whether visually intellectually, or electronically, to make timely, accurate decisions. The tension between excessive control and loss of control has been described as a rider of a horse with a firm grip on loose reins.[61] A commander's exercise of control over his subordinates may appear loose until the action requires his personal direction. Technology must provide the commander the necessary information to maintain the firm grip on the reins.

History illustrates some of the challenges of technological innovation. The British and Germans used the telegraph and telephone to support radically different C^2 philosophies. In their day, these were major technological innovations. Today, however, we have access to a much greater and rapidly improving technological base. At issue is how to best apply it to the C^2 challenges on the modern battlefield.

IV. ANALYSIS OF AUTOMATION TECHNOLOGY

The US Army's investment in modernizing its automated command and control system revolves around the desire to improve the tactical commander's ability to see the extended battlefield, enhance his situational awareness, and assist his decision making ability. Current Army tactical command and control systems (ATCCS) such as the maneuver control system (MCS) require significant manual inputs from an already heavily committed staff, particularly at the battalion and brigade level. While the information presented is useful to the staffs of higher echelons it is seldom useful at brigade and below.[62] Additionally, the MCS is a large, cumbersome machine requiring the vehicle to be stationary to use the system. This requires MCS to remain at the command post and making it difficult to operate during offensive operations. However, the US Army is presently investing in a new

family of automation.[63]

While ATCCS provides automation to brigades and above command posts, battalion and below command and control (B^2C^2) provides the basis for all future automation of C^2 at the lower echelons. Within B^2C^2, the inter-vehicular information system (IVIS) is a developmental system on the M1A2 tank that resembles B^2C^2's objective system for all mounted units. While most future automation systems are in a conceptual stage, IVIS is in prototype form and undergoing evaluation. There is a similar system for use by dismounted infantry and army aviation. The major improvement of these systems over their predecessors is their automatic and semiautomatic flow of information to one another through compatible software and hardware and digital communications.[64]

B^2C^2's objective system will be mounted in every combat and combat support vehicle. It provides a display for the vehicle commander that graphically depicts other friendly vehicles, and any enemy systems identified, the terrain, and the graphic control measures his unit is using. This is referred to as the common battlefield picture.[65]

Another improvement of the system is situational awareness, or a display of your location relative to the common battlefield picture. This is provided in a near real-time manner, whether stationary or moving, through automatic updates from navigation aids on the vehicle.[66]

These updates are fed into the display at 100 meter intervals for both the host vehicle and other vehicles within the unit. This gives the vehicle commander a perspective of his position within the unit, whether he can observe them or not.[67]

Internal navigation aids provide extremely accurate position location information. The system is accurate to ten meters. On laser-equipped vehicles this accuracy extends to the target as well. The locations of enemy systems, obstacles, or structures can be determined accurately and fed automatically into the common battlefield picture of other unit vehicles.[68] B^2C^2 also provides an portable electronic beacon to assist navigation through obstacles, defiles, and other obstructions. The electronic beacon's signature appears on the electronic display of each vehicle and illuminates the proper path to follow.[69]

Alternately, B^2C^2 can receive information from ATCCS databases providing company commanders information from intelligence platforms operated by brigade and division. It can also provide the location and activity of adjacent units. This top-down and horizontal flow of graphically portrayed information can be added to the common battlefield picture as desired.[70]

Whether identified by internal or external sensors, enemy systems can be displayed selected for engagement by

any one of the available systems. Some targets may be handled by direct fire, with the unit or system specified for the engagement. Other targets may be selected for neutralization or suppression by indirect fires when the artillery forward observer can transfer the target data from any of the battalion's systems to the firing unit. Target identification and handover is also possible between helicopters and ground systems.[71]

Another characteristic of the objective system is the hands free vehicle and unit status of key logistics requirements such as fuel, ammo, and maintenance condition. IVIS has embedded sensors in each vehicle that allow other systems to request a status and receive an automatic response. Additionally, leader vehicles can aggregate the status of all subordinate systems and send a consolidated report forward.[72]

IVIS and all B^2C^2 systems include tailorable filtering technology for simplifying the display. Vehicles may be displayed with icons for individual vehicles or aggregated to display units. This allows the vehicle commander to tailor the system to provide the desired level of situational awareness for his position[73]. For example, a company commander may choose to display all of his vehicles as icons, those of his sister companies as platoons, and adjacent battalions as companies.

Lastly, B^2C^2 provides leaders with an analytical tool to speed decision making. Prior to battle, the commander or his staff can calculate time-distance problems, calculate anticipated logistic consumption, or wargame a course of action. During the battle, they can compare actual and planned usage and adjust accordingly. The system will not recommend a particular course of action, but it will provide tools to assist in analyzing available ones.[74]

This monograph will examine the proposed objective system of the Army's battalion and below command and control (B^2C^2) program within ATCCS. These systems are vastly different from those normally referred to when discussing current ATCCS automation such as MCS. They may provide a revolutionary leap in information technology. Not since Frederick have leaders been able to see the disposition of their units in such detail. Conceivably, every vehicle commander could view every other vehicle in the area. At issue is whether the US Army's command and control doctrine should shift from its present decentralized methods to a more centralized C^2 doctrine in response to this technology.

V. ANALYSIS OF TENETS OF ARMY OPERATIONS

This monograph uses the tenets of Army operations to analyze the utility of the Army's current command and control doctrine in respect to the anticipated automation systems discussed above. The five tenets are the basis for the development of all current Army doctrine and tactical techniques.[75] These tenets represent the foundation for the Army's current doctrine. If future automation systems are to change the Army's C^2 doctrine, this wil' become apparent when analyzed by these tenets.

Initiative

Initiative has two general meanings, one for the force as a whole and the other for the individuals within it. Initiative for the force "sets or changes the terms of battle by action...to force the enemy to conform to our operational purpose and tempo while retaining our own freedom of action."[76] The force must overcome inertia and strive to keep the enemy off balance. Inaction, inertia, and reacting to the enemy are symptoms of losing the initiative.

For individuals, initiative is defined as "a willingness and ability to act independently within the framework of the higher commander's intent."[77] Decentralized command and control supports initiative since leaders of subordinate units cannot wait for decisions by their superiors for every situation. Instead

subordinate leaders must make decisions, guided by the commander's intent, if the Army is to maintain the initiative relative to the enemy. "Overcentralization slows action and leads to inertia" on the modern extended battlefield, with its high tempo for operations.[78]

Initiative represents a key tenet for command and control doctrine. It is the source of the Army's desire to decentralize decisions to "the lowest practical level" because it is the key to overcoming inertia and inaction.[79] Future C^2 doctrine and future automation systems must support the requirement to generate tempo and operational purpose quicker than the enemy.

A higher commander must receive extensive knowledge of a subordinate's situation if he wants to control his action. Will automation provide it? B^2C^2 provides a commander near real-time information of his subordinate's location, direction of travel, supply status, and general knowledge of the terrain. The enemy situation is as clear as the information available from his subordinate's system and from the assets available at his and higher's headquarters. These are all improvements on the present systems. But B^2C^2 does not provide all the information necessary to support centralized decisions and prescribe subordinate actions in detail.

While, the common battlefield picture presents information in a format that is easily understood and will

assist commanders at all levels in clearly transmitting orders, it does not present all the information available to the leader at the scene. For example, the electronic map illustrates all the features normally available on a map of the same scale. Yet, maps cannot describe the terrain in sufficient detail to detect folds in the ground large enough to hide a vehicle, a bunker, or a platoon of soldiers.

Additionally, a leader in the battle has an awareness of the effects of the moral domain on himself, his soldiers and the battle as a whole. The future automation systems do not assess fatigue, morale, or training status; factors which influence the unit's combat capability and are essential considerations for most combat decisions. These factors are readily apparent to the unit's leadership, but are not part of the common battlefield picture. Therefore, leaders should not expect automation to provide an assessment of moral factors.

Obtaining this information requires direct observation of the unit in question or numerous radio transmissions to get all the necessary information. Some factors, such as fatigue, fear, and a subordinate's comprehension of instructions are difficult to judge with any communication means. Multiplying this example by the number of units on the battlefield indicates the magnitude of the problem. For example, a brigade commander would need this level of

detail for over twenty maneuver and combat support companies to effectively centralize control at his level. The magnitude of the necessary information is beyond B^2C^2's capacity during modern, fast-paced battles.

It is apparent that while automation provides a significant improvement in information going to higher commanders, it does not replace the need for subordinate leaders' initiative. Historical experience and US Army doctrine indicate that centralized decisions slow the tempo of operations at times leading to inertia. B^2C^2 fails to correct the problem.

However, the intent of initiative is to "force the enemy to conform to our operational purpose and tempo."[80] In some circumstances, such as in operations other than war, the enemy's tempo may be very slow giving a higher headquarters the time necessary to centralize decisions. Occasionally, the operation may be extremely complex with subordinates having little training and experience in the task. This would also represent another opportunity to centralize decisions at the level where the experience exists. B^2C^2 supports both situations by reducing uncertainty in the situation and increasing the transmission speed and clarity of instructions.

B^2C^2's automation does not appear to support a shift to centralized decision authority, except in slower, more complex operations. But, will it support the present C^2

doctrine? Two capabilities of B^2C^2 are of interest, the common battlefield picture and situational awareness.

The common battlefield picture maintains a simple graphical display of the unit's current situation. Studies reveal that up to seventy percent of present radio transmissions are related to the enemy and that these reports are seldom considered accurate.[81] Additionally, the leader uses the display's host vehicle indicator to describe his position in relation to his unit and environment, providing him with a situational awareness. While terrain features might interrupt the leaders' line of sight to his unit or enemy, automation can maintain his orientation. B^2C^2 greatly improves the timeliness of the information, increases the leader's comprehension of his situation, and reduces the number of transmissions.[82]

Both these features should support initiative from leaders in the battle. Instead of having a vague notion of the enemy's location and a fair assessment of his unit's location and status, the B^2C^2 automation should provide a significantly more accurate and understandable picture of the situation. Orders to subordinates should also improve due to the common battlefield picture and the automated orders function of the system. In this case, a picture may be worth a thousand words over the radio. The information provided by B^2C^2 automation, coupled with the commander's knowledge of his unit and the terrain, should

increase the commander's willingness and ability to make a decision.

Agility

Agility is defined as the ability of units, and their leaders, to act faster than the enemy. It is considered a prerequisite for initiative, for without agility it is unlikely the Army could gain and maintain initiative.[83] Agility's importance to C^2 doctrine is its requirement for leaders to continuously "read the battlefield", decide quickly, and act without hesitation. Staffs must also respond quickly to implement the commander's decision while units must be capable of responding to new instructions or situations.[84]

Agility represents both the Army's positive and procedural control systems. A commander must plan for contingencies and future operations (procedural), see the battlefield to gain a clear and accurate picture, decide on a course of action (positive), then direct his staff and subordinates to implement his decision. An analysis of future automation systems will focus on these key components of agility to determine if they support our present doctrine or whether a new doctrine is necessary.

B^2C^2 graphics, decision aids, and wargaming functions will enhance tactical contingency planning and speed the decision making cycle.[85] By speeding the process, leaders may plan for contingencies and save the files for later

use.

These functions are not restricted to the staff. Every vehicle or system has the same capability, giving each leader the opportunity to plan his actions and reactions. While the task force commander plans for contingencies, the company commanders, specialty platoon leaders, and staff can also plan. Once complete, the plans can be exchanged, modified, and saved for future use. Centralizing the planning is not necessary, and may be detrimental since it would slow the process, with a few individuals attempting to plan all facets of an operation rather than many planning simultaneously.

Automation may significantly improve a unit's ability to execute current C^2 doctrine. Today, the higher commander spends much of his effort allocating and shifting resources to support the fight.[86] The essence of agility is to shift units and resources quickly to support the decisive point in the battle. Enhanced situational awareness, increased speed of planning, and ease of coordination between units due to a common battlefield picture will contribute to a more agile force.[87]

The common battlefield picture will allow the commander to better see the situation. Previously, the soldier and his leaders were limited to their direct observation of the battlefield and what they could envision from radio transmissions. In the extended, high

tempo battlefield, this view can be fragmented and incomplete. Uncertainty about the true situation results from this fragmented view of the battlefield slowing decisions.

Studies reveal that the timeliness of information and uncertainty concerning the validity of this information, lengthen the decision cycle significantly.[88] However, the near real-time, graphical displays of friendly and enemy units in relation to the leader's current location should greatly increase the certainty and timeliness of his information, giving the tactical leader the confidence to quickly decide on a course of action.[89]

Speed in executing the commander's decision should improve with automation-supported orders. The on-board computers provide hard copy printouts and screen displays of instructions. Graphics and messages transmitted electronically will speed dissemination of the order.[90] Also, units will be capable of receiving new orders while on the move, a nearly impossible task today.

The common battlefield picture will ease coordination requirements since adjacent and supporting units will electronically see the same battlefield. Radio messages with detailed descriptions of the situation may prove unnecessary. Interactive communication between B^2C^2 compatible systems would produce a common view of the situation. The commander and his supporting units would

quickly produce a common set of graphic control measures and gain a shared expectation of the chosen course of action.[91] The common battlefield picture could reduce much of the friction inherent in current coordination methods.

<u>Depth</u>

"Depth is the extension of operations in time, space, and resources... To think in depth is to forecast, to anticipate."[92] Tactically, depth means gaining information concerning the enemy and attacking him throughout his formation to include attacks on his flanks, rear, and support echelons. It also demands predictive analysis from commanders and their staffs. Predictions of a unit's location and fuel status at a future point in time, where the enemy reserve will be committed, or what will constitute friendly actions after this operation, are examples of thinking in depth. Whether C^2 systems and doctrine assist the commander and staff in visualizing the battlefield in depth and predicting future actions is the issue.

Ironically, current systems support centralizing decisions at the higher headquarters. For example, currently data fusion of intelligence information primarily occurs at the corps main command post, with division command posts having a limited capability. J-STARS, and other electronic systems; national systems; and most photo imagery are processed through the corps

analysis center and disseminated to divisions and brigades through the ATCCS all-source analysis system (ASAS).[93] The intelligence then flows down to divisions and brigades. This intelligence is transmitted initially in message format to subordinate headquarters, then over voice lines such as telephone and radio to commanders in the fight.

This complex and slow communication process severely limits the usefulness of higher's intelligence products to the tactical commander. While the tactical commander's decisions are hampered by uncertainty, the corps commander's confidence increases since he gets a near real-time display of the information. It is not hard to imagine a return to the British experience at the Somme, with the High Command controlling the tactical fight due to the perception of omniscient information.

B^2C^2 combines the information from the unit's internal sensors, such as lasers which may range five kilometers forward of the unit, with external sensors, such as ASAS or OH-58D's, for intelligence of the enemy deep. B^2C^2's access to both internal and external intelligence greatly improves the leader's situational awareness throughout the depth of the battlefield.

Another B^2C^2 capability supporting depth is computer-assisted time-distance and logistic calculations.[94] Commanders and the staff can calculate the time and

resources necessary to execute a given course of action. More importantly, they can detect any deviation from the calculation as the unit progresses. They can also project new timelines and resource requirements. The ability to calculate requirements based on various courses of action and based on actual consumption will allow the commander and his staff to anticipate unit needs.

Tactical units will benefit from the introduction of B^2C^2 through its access to internal and external sources of intelligence and calculations of logistic and time-distance factors. These capabilities will provide the commander information throughout the depth of the battlefield and improve his ability to anticipate unit requirements.

Synchronization

Synchronization represents another key tenet along with initiative. FM 100-5 describes synchronization as a process and a result that uses "time, space and resources to produce maximum relative combat power at the decisive time and place."[95] Some writers have observed that synchronization often demands centrally formulated, detailed plans to work.[96] Doctrine also states that synchronization "requires explicit coordination among the various units and activities participating in any operation."[97] At the tactical level, "explicit coordination" often generates detailed orders and

significant control requirements to ensure that the timing and effect of numerous activities compliment one another. This need for effective synchronization of all assets contributes to the tendency toward centralized control.

Part of the problem appears to be the organizational echelon for the synchronization of forces and activities. Current C^2 systems support centralized control since brigades and divisions, bear the burden of synchronizing activities. Commanders at these levels control the resources, possess the necessary information, and have access to systems for communicating with all the units involved.[98] Currently, company and battalion commanders lack these capabilities.

Another difficulty facing tactical commanders is the uncertainty of the battlefield situation making it difficult to discern a decisive point and focus combat power. Because tactical commanders cannot currently see the battlefield accurately unless they are in close contact with the enemy, the higher commander, who can often see the enemy, is able to apply combat power before maneuver forces make contact. However, if a subordinate leader adjusts his axis or speed due to local conditions, the timing, location, and effects of supporting systems may fail to support his maneuver. In sum, the gap in the tactical information available to higher and lower commanders induces a lack of synchronization between the

subordinate's tactical maneuver and higher's combat support efforts. The battle is no longer synchronized.

The focal question is whether automation will solve this dilemma of synchronizing forces and effects. A battle centrally synchronized may limit subordinate initiative, but a decentralized operation will be more difficult to coordinate during fast-paced combat. At issue is whether future automation systems can enhance the tactical commander's flexible and timely employment of all available assets.

The common battlefield picture will enhance synchronization of fires during the close battle. For example, indirect and direct fires can be quickly and accurately massed on a chosen target as never before. Interactive control of fires can significantly increase the lethality of the forces in contact. Fires need not be redundant or fail to engage some enemy targets due to poor means of control. Commanders will be able to see the enemy they wish to isolate and those they wish to destroy. The commander, the forward observer, the helicopter pilot, and other supporting systems have a common picture of the situation. This common picture will simplify and speed the commander's instructions to supporting units. Additionally, fratricide can be avoided with the common battlefield picture available to all firing systems.[99]

Besides fires, B^2C^2 can assist commanders in synchronizing maneuver forces through the use of electronic beacons. These beacons, carried by engineers and others, will provide the ability to quickly mass at breach sites, bridges, or weak points in the defense, while fires isolate the area accurately. B^2C^2's situational awareness and navigation capabilities will speed the coordinated movement of all equipped units through the electronically illuminated area while identifying the point for synchronization of fires.

Automation will assist synchronization of the sustainment effort with the operation. Logistic and maintenance reports automatically fed to the appropriate headquarters will enhance the sustainability of the effort, particularly with automated consumption analysis predicting when the unit will reach a critical condition. The unit's staff can prioritize logistic efforts based on the commander's plan, the B^2C^2's near real-time logistic updates, and projected usage based on current consumption rates.

Synchronization will not only improve with B^2C^2, but responsibility may shift to subordinate leaders. Leaders at the decisive point will integrate and deconflict direct, indirect, and aerial delivered fires; mass maneuver forces, and synchronize sustainment with the operation. The brigade and division commanders need only

allocate the resources to the battle; the battalion and company commanders have the means to synchronize their employment. This will support decentralized methods of control.

<u>Versatility</u>

In a smaller Army each unit must be capable of performing in a multitude of missions and environments. Versatility, our newest tenet, describes the "ability to shift focus, tailor forces, and move from one role or mission to another rapidly and efficiently."[100] Versatility differs from agility which refers to the speed with which we execute our present task and the flexibility necessary to adjust our method. Versatility refers to the same unit quickly switching to a new task, possibly one not on the unit's METL.[101] A versatile unit may perform combat operations during war; then police a war-ravaged city until civil authority is established. B^2C^2 supports a wide range of environments and missions due to its ability to transmit a common picture, position location, and orders vertically and horizontally within a unit.

The position location attributes of B^2C^2's navigation system will assist commander's in any environment. Knowing the location of soldier and systems within the unit remains an essential task of leaders. While knowing their location in relation to one another is extremely helpful.

The common picture and situational awareness represent a useful function regardless of the nature of the activity. When participating in an operation other than war such as firefighting, policing a city, or disaster relief, a common picture of the situation will assist leaders at every echelon.

Additionally, the graphic and printed orders capability will facilitate any operation. The message format is normally used for operations orders, overlays, and other standard reports, however, it may be tailored to transmit new rules of engagement, descriptions of wanted criminals, or instructions on safe routes through a fire.

B^2C^2 also supports flexibility in modifying methods of control. The doctrine of directive control implies a knowledgeable subordinate capable of developing an adequate plan for the task. However, versatility may require a unit to perform a task for which it has little training. For example, when a unit is involved in operations other than those for which it has trained, it may lack the necessary expertise, or have limited numbers of individuals with the requisite skills. Then, a more centralized, prescriptive method of control may be required. B^2C^2's system is capable of giving great control of a unit's actions to a higher headquarters, where the expertise may reside.

Operations other than war provide the best example, though not the only example, of situations requiring versatility in units. US Army units may not always operate on the high tempo battlefield for which they are trained. Operations other than war are often complex, with multiple rules of engagements and significant political considerations. Regardless of the situation future automation will facilitate understanding information and orders.

VI. CONCLUSIONS

The US Army has chosen a command and control doctrine that resembles what BG Richard E. Simpkin calls directive order control, with considerable initiative expected from subordinates. Commanders are given great latitude in positioning, but tactical commanders are generally expected to position forward. The foundation of the Army's doctrine is on gaining and maintaining the initiative, having units and leaders of great agility, leaders that think in depth and can anticipate, synchronization of units and activities to support the fight, and versatile units capable of quickly shifting tasks. These tenets are best achieved through decentralized command and control.

Previous ATCCS systems appear to support the view that technology increases centralization since most ATCCS

systems are found only in command posts above brigade level. They also require substantial effort from tactical echelon staffs to manually input information for use by higher staffs while providing higher commanders with the means for excessive control of subordinates.

However, B^2C^2's automation does not seem to support that conclusion. The automatic and semiautomatic method of receiving, displaying, and transmitting information eliminates much of the labor. Mounting the system in combat vehicles means it can serve the lowest tactical echelons. Access to top-down and bottom-up information will give leaders a relatively detailed view of the battlefield. Many laborious functions in decision making at the tactical level will be eased by the electronic and hard copy orders readily available through B^2C^2.

Although most information provided by automation concerns the physical environment of the battle, not all of it is sufficiently detailed to make war a game of chess. Additionally, the moral factors of training, morale, fatigue, and motivation are not available. Higher commanders would have to revert to lengthy radio conversations or personal presence to get this information. For these reasons, it appears that automation will not normally support centralized prescriptive control, with some exceptions.

First, if the higher commander positions with the unit, the combination of displayed information and his personal knowledge of the situation would support his control of the battle. Occasionally, the use of a directed telescope in addition to B^2C^2's automation might allow the higher commander to centralized control. Both of these options have historical precedence and automation merely speeds the flow of information.

Second, if the situation's pace is slow and extremely complex, such as during an operation other than war with complex rules of engagement, B^2C^2 may assist the higher commander in centralizing decisions at his level. Since future automation systems are capable of rapid information flow, up, down, and horizontally, they will facilitate either method of control. The maintenance of initiative relative to the enemy is key to this decision.

Future tactical automation supports the current C^2 doctrine of decentralized control. Tactical commanders will better see and understand the battlefield, thereby improving the accuracy and timeliness of their decisions. While the information available to higher commanders will also improve, it will usually be insufficient to justify centralized control of tactical operations. Thus the commander may position where he can best influence the battle while retaining access to the information provided by B^2C^2.

Appendix A: IVIS Hardware on M1A2 Abrams Tank

1. General. The following system description is centered around the core tank and its components. It is this collection of components that provide the vehicle and its crew with the set of system functions and capabilities that have been termed the Intervehicular Information System (IVIS).

2. Core tank definition. The M1A2 core tank is a term used to conveniently designate the collection of hardware, firmware, and software that must be modified or added to facilitate integration of mission modules (sometimes called subsystems). These modifications or additions are necessary to fully develop the data and power bused architecture featured in the M1A2 tank. The core tank is not a stand-alone system in and of itself, but by design is a technical means for systems integration within the M1A2 configuration.

3. Core tank components.

A. *Data management system (MIL STD 1553B Data Bus).* The MIL STD 1553B data bus system is the primary means for command and control of the M1A2 electronics system. The bus controller initiates bus transactions (messages) by issuing a command to the selected remote component. The remote component receives the command, receives or transmits data as directed, and responds with a status word. The command-response protocol implements the positive central control philosophy of the bus concept and ensures feedback on message status. This means that there is centralized control of data traffic on the bus, this eliminating bus contention. Line Replaceable Units (LRUs), or system components, "talk" only when the bus controller issues a command.

B. *Power management (RS 435 electrical interface).* The power control (utility) bus is used to allow the decentralization of electrical power distribution through the use of a low-cost, multidrop serial bus interconnecting remote programmable-controlled semiconductor switches to facilitate power control (and remote analog/digital modules to facilitate built-in-test [BIT]). The power bus uses an RS 485 electrical interface to a multidrop serial utility bus. This system replaces most of the turret networks box (TNB) and hull networks box (HNB) functions with respect to power management.

C. *Modified Slipring Assembly.* The slipring assembly provides the link between the hull and turret. The M1A2 has a modified slipring that accommodates the changed number of circuits required, including the redundant MIL STD 1553B data bus and power distribution utility buses, with shielding added to some circuits.

D. *Hull Electronics Unit (HEU).* The hull electronics unit provides the control, communications, and processing core of the hull electronics system. It includes the processing power to manage the power management bus and acts as backup bus controller for the MIL STD 1553B data bus. It essentially serves as the auxiliary system supervisor. It also provides engine diagnostics reporting and Position Navigation System (POSNAV) computation and management. The HEU communicates with the turret electronics unit (TEU) and provides two-way functional redundancy between the HEU and the TEU. If the TEU fails, the HEU will perform its critical functions and vice versa.

E. *Turret Electronics Unit (TEU).* The TEU provides the control, communications, and processing heart of the core electronics system. It is the primary system supervisor/ executive and manages the MIL STD 1553B data bus. It includes processing power for backup to the power management system. The TEU also provides fire control computations.

F. *Fire Control Electronics Unit (FCEU).* The Fire Control Electronics Unit replaces part of the Turret Networks Box (TNB), provides for system integration of the hunter/killer mode (using the Commander's Integrated Thermal Viewer (CITV)) and main gun firing, and incorporates the armament enhancements into the fire control system. It integrates the CITV with the fire control system through the Gun Turret Drive (GTD), line of sight (LOS)/data link and TNB fire control functions. It performs all current ballistic computer functions in addition to providing for dynamic cant data from the POSNAV system and the hull-turret position sensor.

G. *Hull-Turret Position Sensor (HTPS).* The hull-turret position sensor provides a signal to the FCEU which indicates the relative angle of the hull and turret. This angle is used to resolve the POSNAV hull roll and pitch angles to provide a turret dynamic cant signal. This replaces the current cant sensor when POSNAV is integrated into the M1A2 tank. HTPS also supports the concept of "far target" location (lasing to a target and getting an accurate 8 digit grid location for automatic input into preformatted tactical messages).

H. *Digital Engine Control Unit (DECU).* The digital engine control unit replaces the existing analog electronic unit (ECU) and provides improved control and monitoring of the engine system resulting in reduced fuel consumption and improved reliability. Additionally, the DECU provides extensive engine diagnostic information which is provided to the crew via the driver's integrated display (DID).

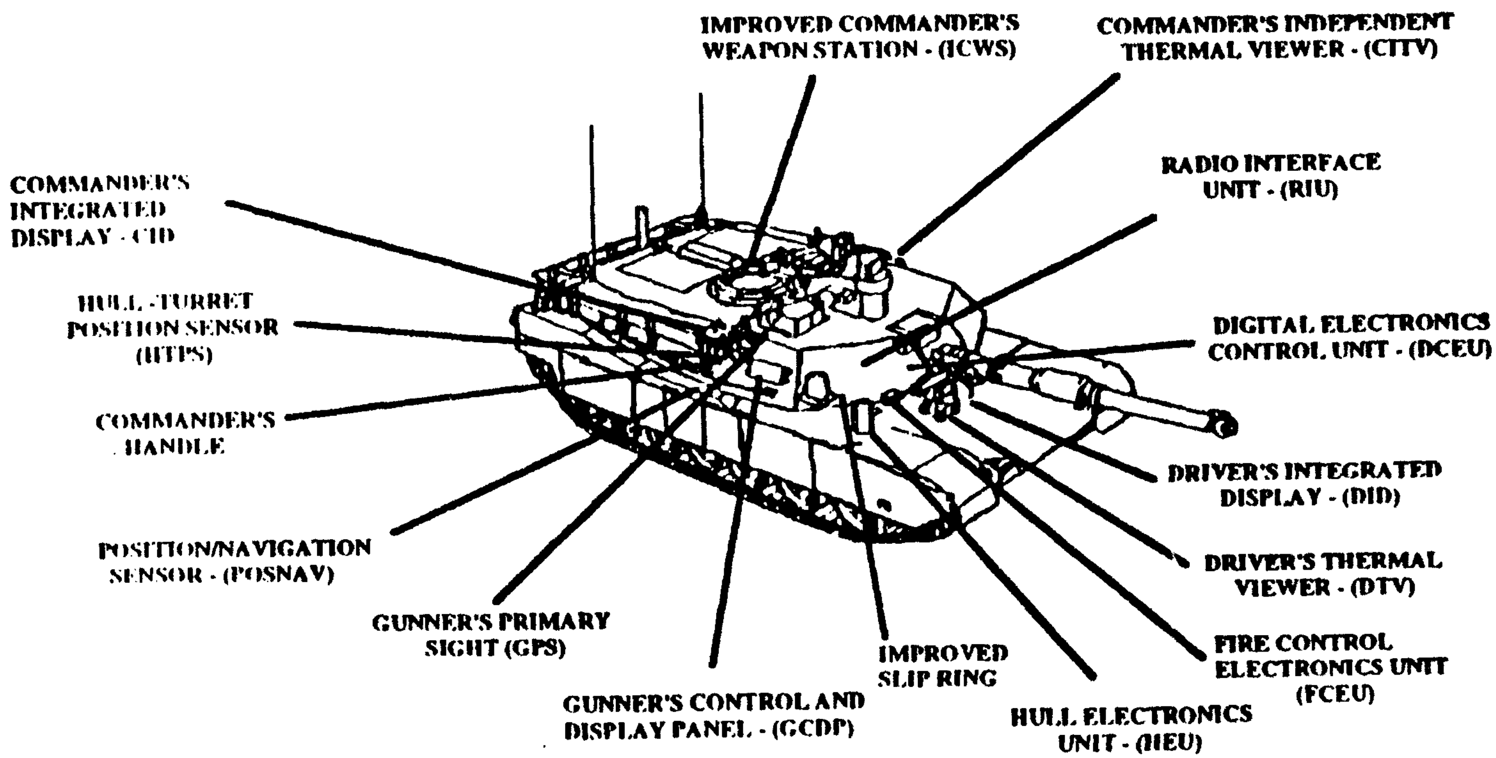
I. *Commander's Integrated Display (CID).* The CID is the tank commander's primary soldier-machine interface (SMI) with the M1A2 tank. It combines in a single unit the display and control of the CITV and the command, control, and

communications functions through the core electronics system. It replaces the current tank commander's panel (TCP). The CITV video display screen is a direct view device with sufficient resolution to allow the incorporation of daylight television viewing at a later stage without the need for internal modifications. CITV controls are collocated with the display. Control and display of communications, POSNAV, BIT, and other operator and tactical functions occupy the remaining area of the CID.

J. *Gunner's Control and Display Panel (GCDP)*. The gunner's control and display panel provides the new interface required by the TEU's fire control computation function and continues to provide the control and display function of the replaced gunner's computer control panel (GCCP). The GCDP interfaces to the vehicle subsystems through its MIL STD 1553B data bus interface which provides the FCEU and TEU with data to calculate and resolve ballistics.

K. *Driver's Integrated Display (DID)*. The driver's integrated display is the driver's primary SMI with the M1A2 tank. It replaces the existing driver's instrument panel (DIP), the driver's master panel (DMP), and the driver's alert panel (DAP); it provides all their control and monitoring functions. It also monitors all engine system status and control signals transmitted from the digital engine control unit (DECU) and communicates with the HEU. The DID also provides the driver with navigation information heading and "steer-to" display.

INTERVEHICULAR INFORMATION SYSTEM



CAPABILITIES

- *NAVIGATION*
- *COMMUNICATIONS*
- *SYSTEM HELP*
- *DIAGNOSTICS*
- *MISSION PLANNING*
- *DATABASE MANAGEMENT*

FIGURE 1. Intervehicualr Information System (IVIS) Architecture

Appendix B: Example of Situational Awareness

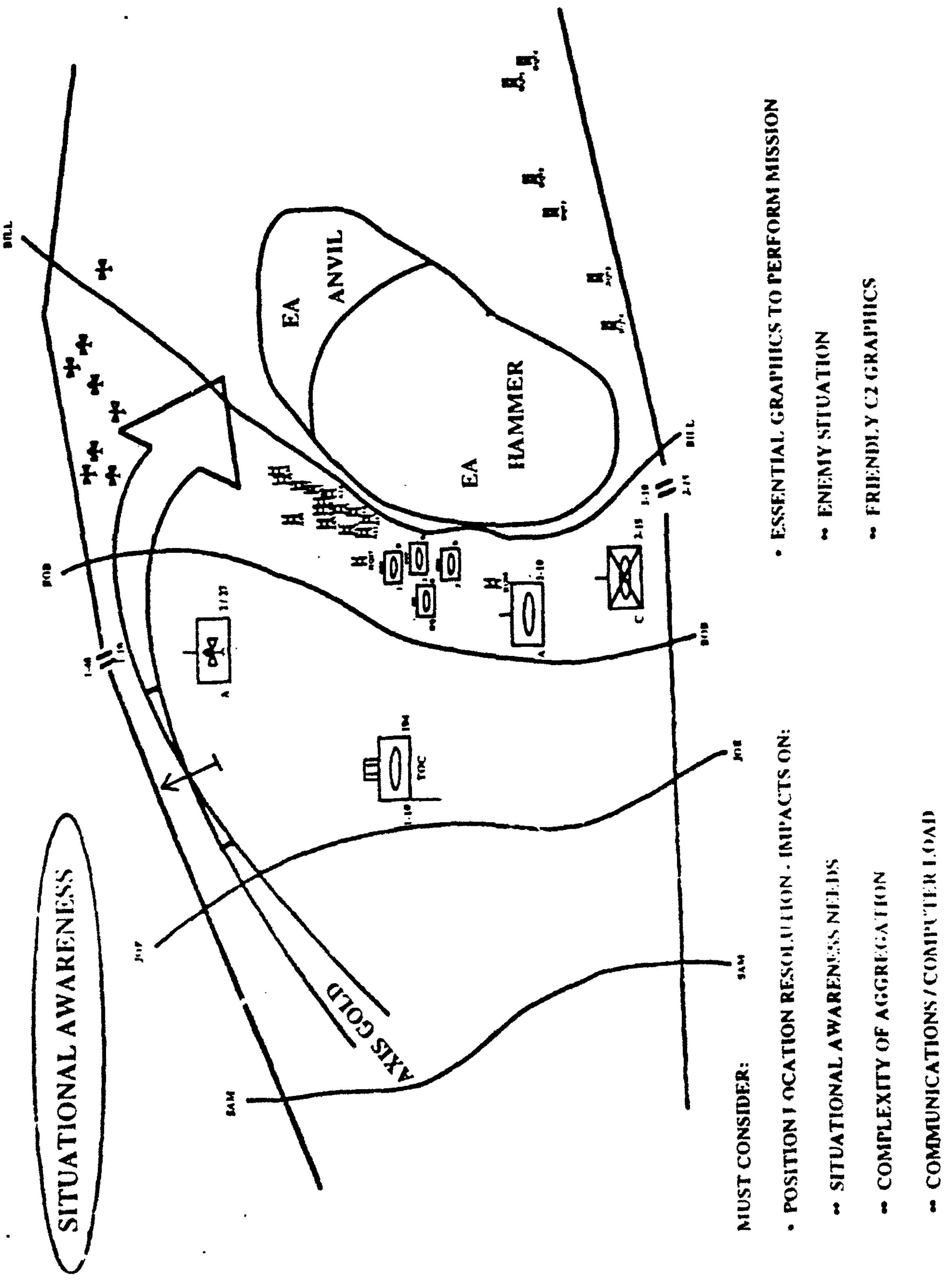
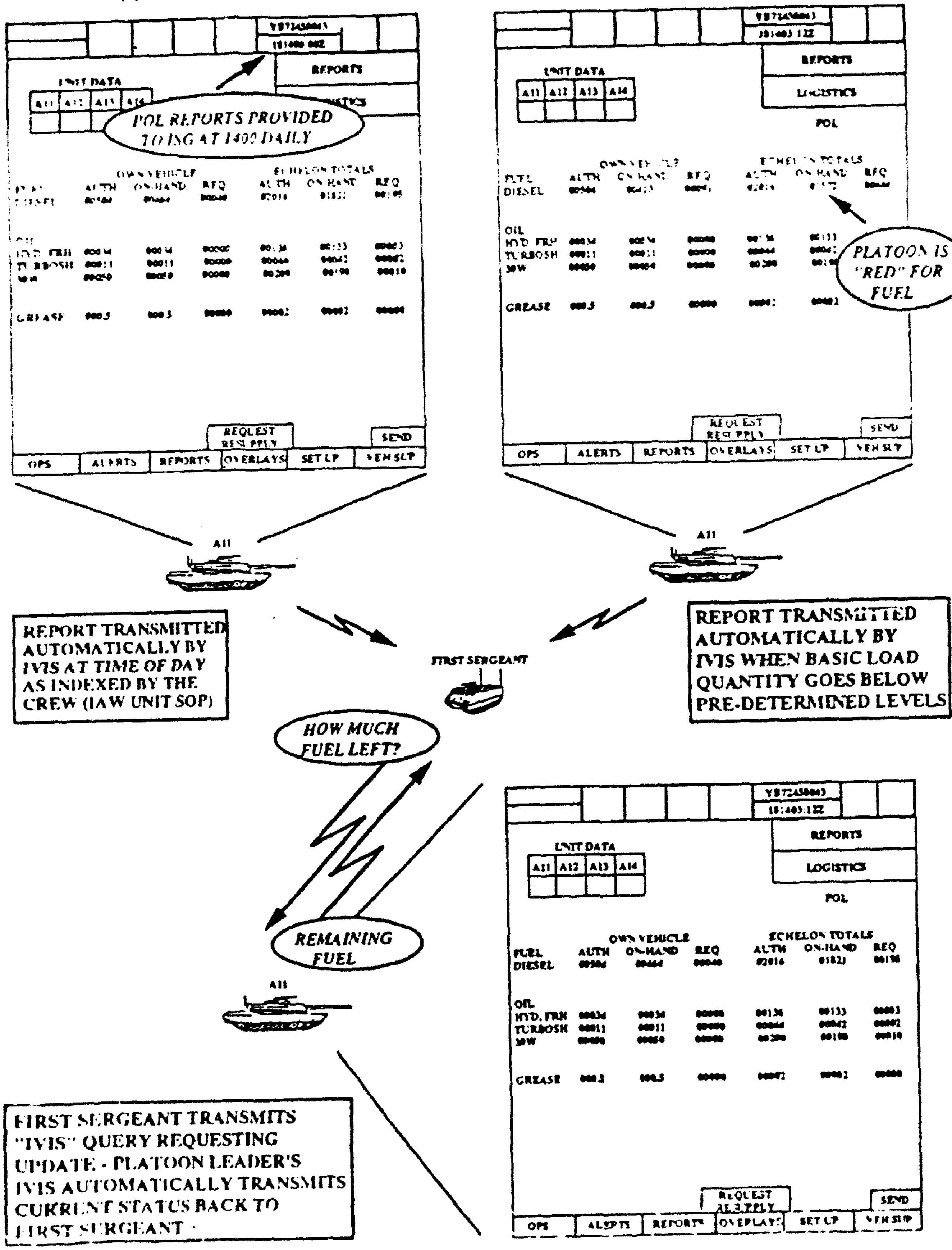
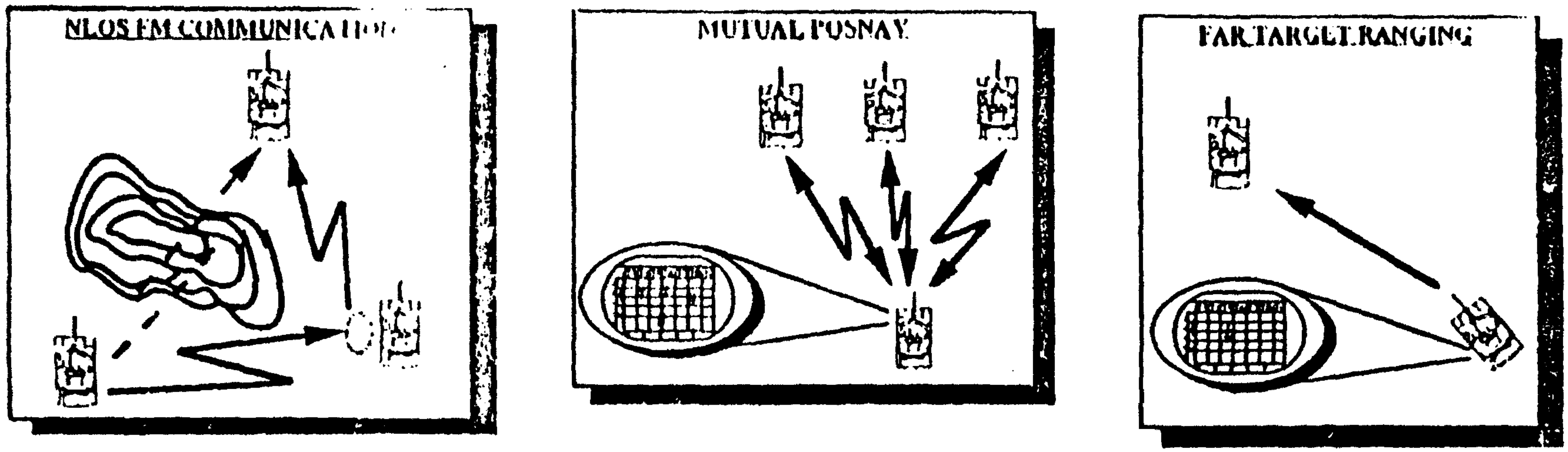


FIGURE C-3. Considerations When Exchanging IVIS Data Between Aviation and Ground Forces

Appendix C: Example Logistic Reports

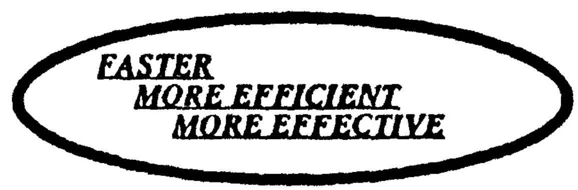


Appendix D: Example Common Battlefield Picture



COMMON BATTLEFIELD PICTURE

- *AUTOMATIC POSITION LOCATION OF FRIENDLY VEHICLES / UNITS (MUTUAL POSNAV)*
- *AUTOMATIC FM RETRANS*
- *AUTOMATED SITUATION REPORTING - METT-T*
- *EXCHANGE OF MISSION GRAPHICS AND CONTROL MEASURES*



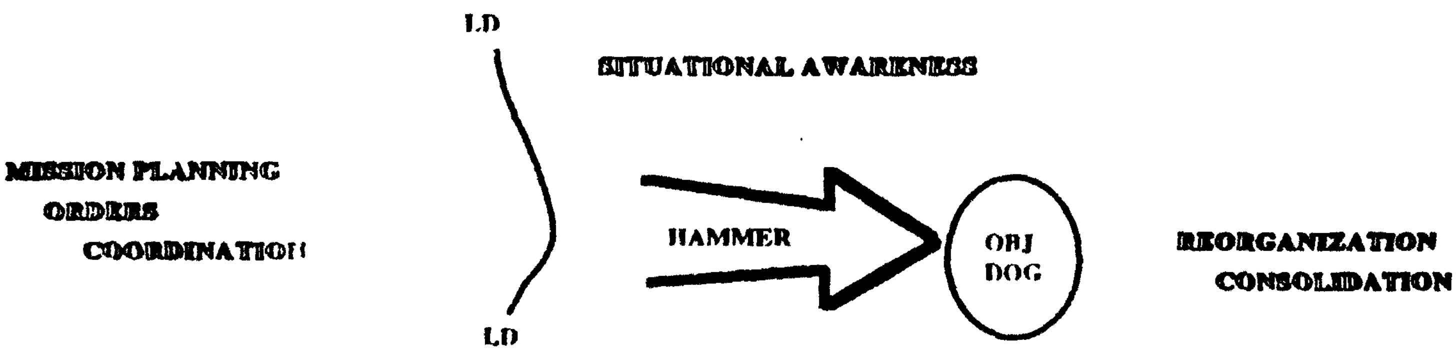
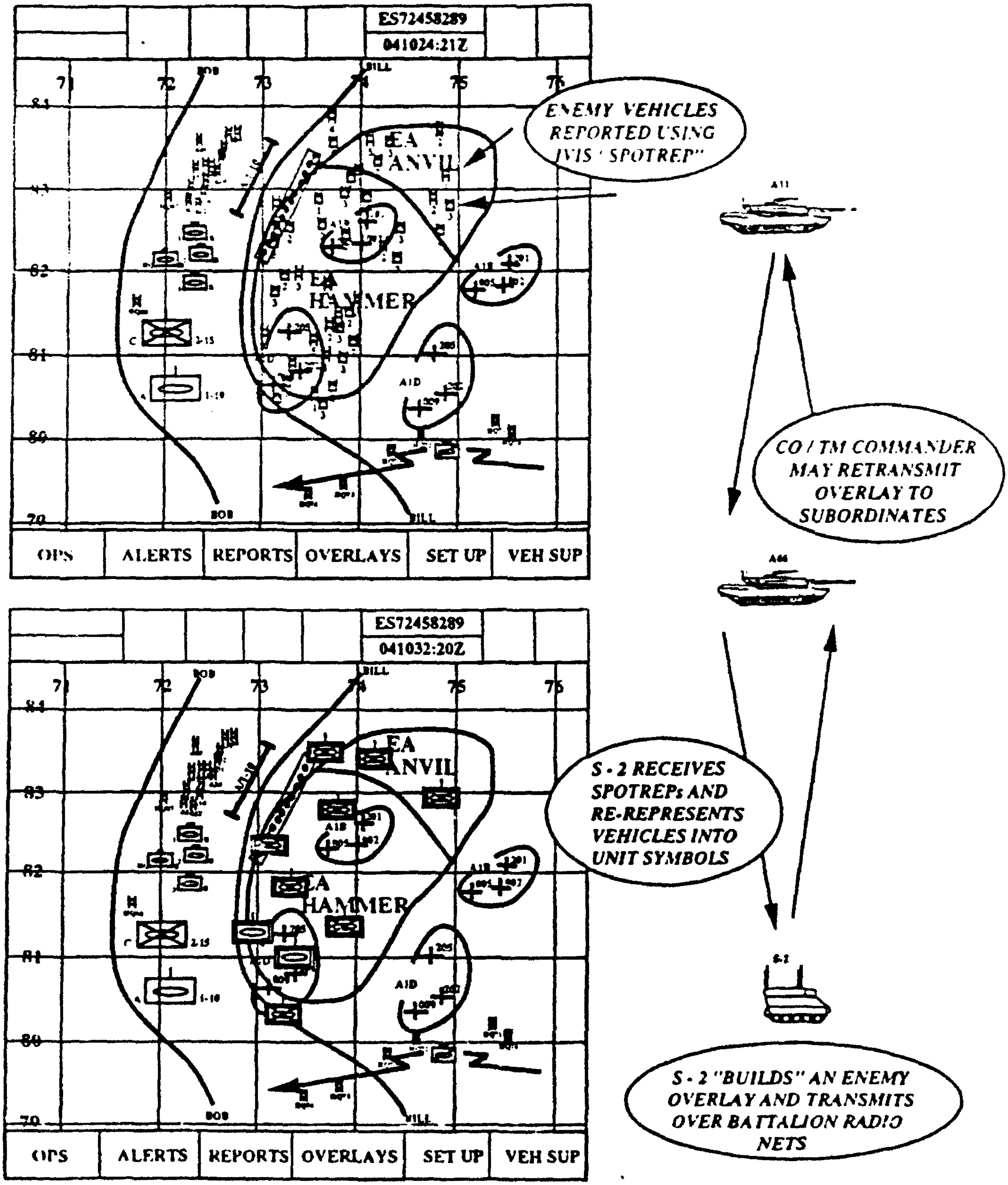


FIGURE 2. Intervehicular Information Sharing

Appendix D: Example Common Battlefield Picture



Appendix D: Example Common Battlefield Picture

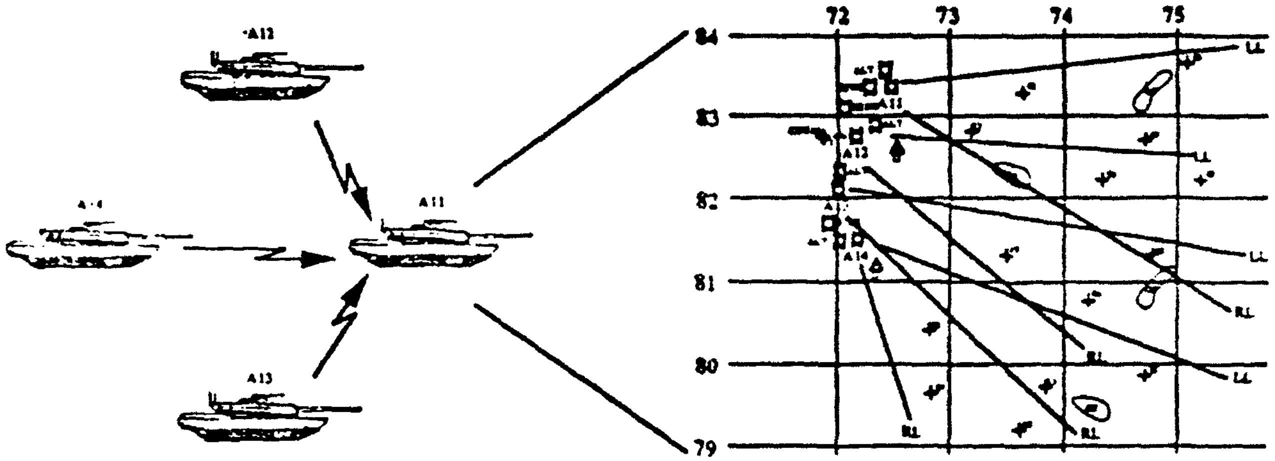
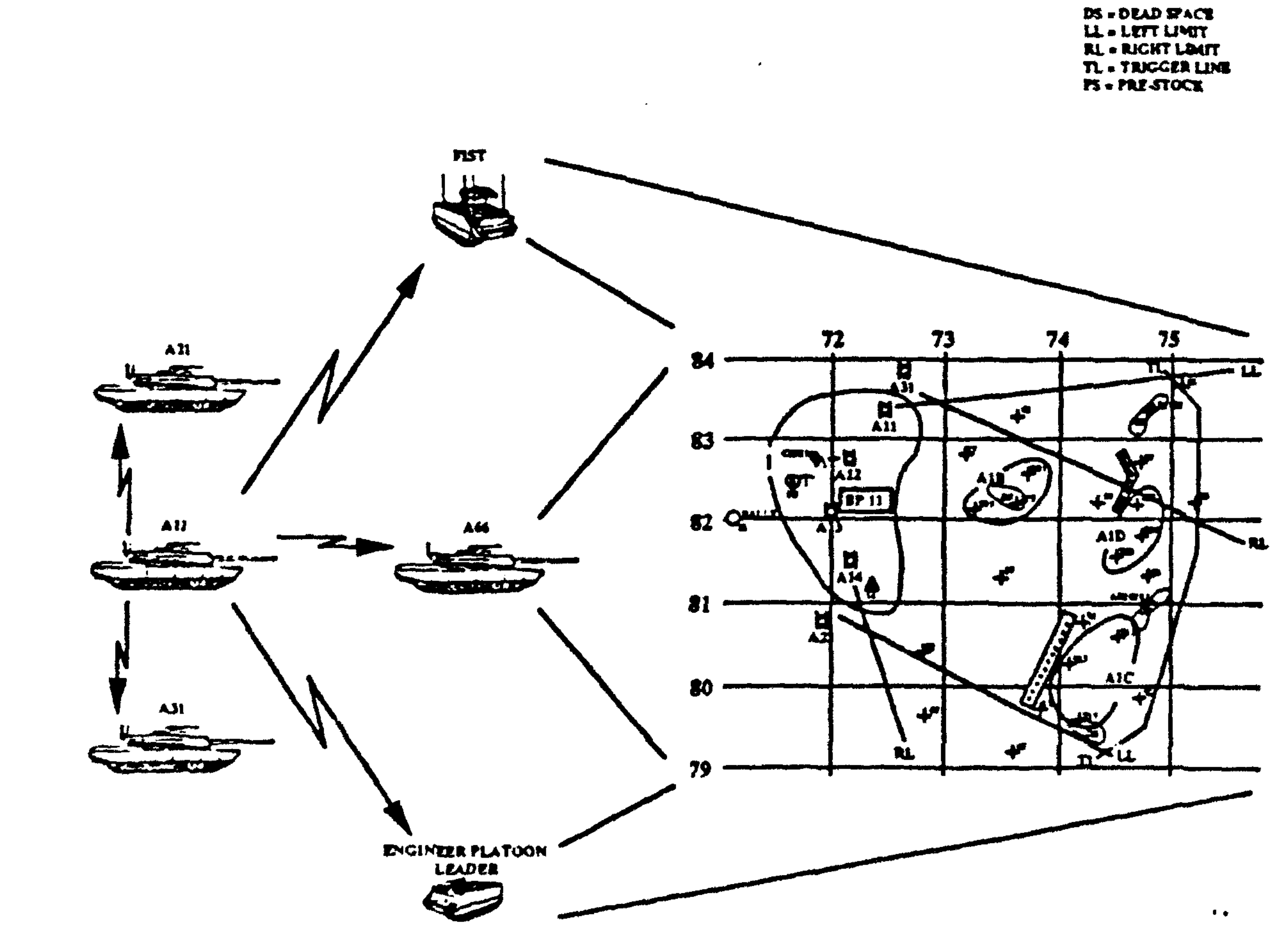
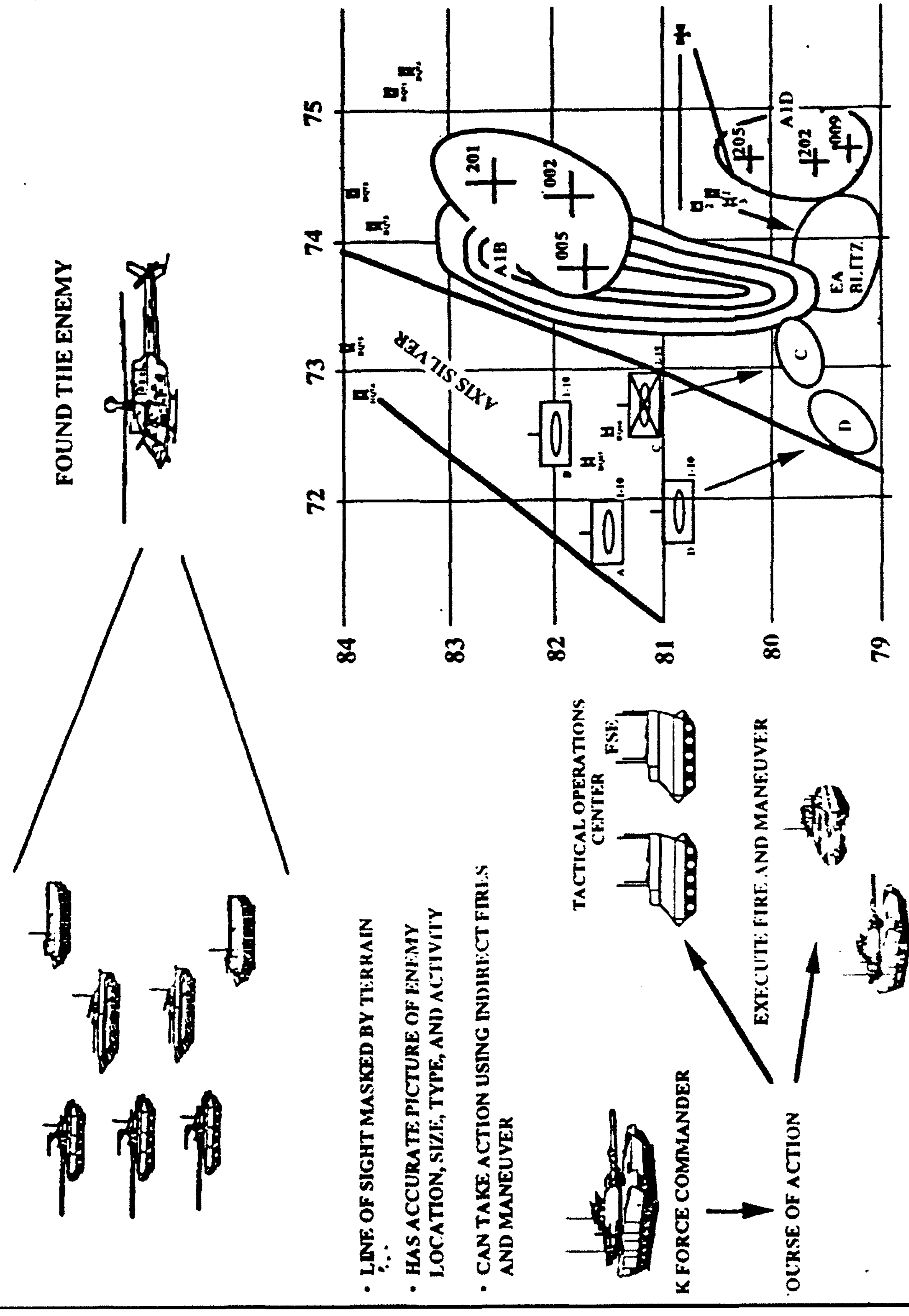


FIGURE 5. Platoon - Pre / Post Combat - Consolidated Vehicle Direct Fire Sketches



Appendix D: Example Common Battlefield Picture



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30. Ibid, 97.

31. Ibid, 97.

32. Keegan, pp. 185-191. The author describes an infantry square in combat and the role of officers and sergeants in controlling the troops within.

33. van Creveld, Command, 52-57.

34. Ibid, 146.

35. Ibid, 121.

36. Ibid, 144.

37. John M. English, On Infantry (New York: Praeger Publishers, 1981), 75.

38. van Creveld, Command, 184.

39. Richard E. Simpkin, Race to the Swift (New York: Brassey's Defense Publishers, 1985), 234.

40. English, 13-14.

41. Keegan, 265-267.

42. van Creveld, Command, 166.

43. Foss, "Command", 3.

44. Robert D. Cox, "Information Pathology and the Army Tactical Command and Control System (ATCCS): Is ATCCS a Cure?" (SAMS Monograph, US Army Command and General Staff College, 1990), 14-17.

45. Richard E. Simpkin, Human Factors in Mechanized Warfare (New York: Brassey's, 1983), 149. The author actually lists five methods in this work, two of which, directive and mission order, he combines in his later book Race to the Swift, 228-229.

46. Simpkin, Race to the Swift, 231.

47. Simpkin, Human Factors, 150.

48. Simpkin, Human Factors, 152-157. Simpkin uses the term "loose rein-tight rein" to describe the centralization phenomenon.

49. US Army, "FM 101-5 Command and Control for Commanders and Staff" Coordinating Draft (Ft. Leavenworth: US Army Command and General Staff College, 1992), 1-4.

50. Ibid, 1-4.

51. US Army, "FM 100-5 Operations" Preliminary Draft (Ft. Leavenworth: US Army Command and General Staff College, 1992), 2-15.

52. Ibid, 2-16.

53. Ibid, 2-16.

54. "FM 101-5", (1992), 1-6.

55. Ibid, 1-7 thru 1-15.

56. Ibid, 1-7 and 1-8.

57. Ibid, 1-4.

58. Ibid, 1-8.

59. "FM 100-5", (1992), 2-17.

60. Ibid, 2-15.

61. Foss, "Command", 5.

62. Patrick Neky, "Mastering Command and Control: The Brigade Commander's Environment in the AirLand Battle" (SAMS Monograph, US Army Command and General Staff College, 1990), 36-37.

63. US Army, "Operational Concept for Battalion and Below Command and Control (B^2C^2)" Draft (Ft. Leavenworth: US Army Combined Arms Center, 1992), 2-4. Hereafter referred to as "B^2C^2".

64. Ibid, 6.

65. "B^2C^2", 7.

66. US Army Armor Center, IVIS Operational Concept, (Ft. Knox: US Army Armor Center, 1992), 9. Hereafter referred to as IVIS.

67. From an interview with Major James Henderson, author of the IVIS Operational Concept, in August 1992.

68. IVIS, Appendix C describes this capability.

69. "B^2C^2", 18.

70. "B^2C^2", 12.

71. IVIS, Appendix C.

72. IVIS, 9.

73. IVIS, 32.

74. "B^2C^2", 13.

75. "FM 100-5", (1992), 2-5.

76. Ibid, 2-7.

77. Ibid, 2-7.

78. Ibid, 2-8.

79. Ibid, 2-8.

80. Ibid, 2-7.

81. [V(INT)2], 88.

82. IVIS, ix.

83. "FM 100-5", (1992), 2-8.

84. Ibid, 2-8.

85. "B^2C^2", 3.

86. Comment by GEN Edwin Burba, CINCFORSCOM, at a Senior Leader's Warfighting Conference at Ft. Leavenworth, 3 Nov 92. GEN Burba's comment concerned the proper role of a brigade commander which was to allocate and shift, as necessary, resources so the actual warfighters, battalion commanders, could do their job.

87. IVIS Operational Concept, 2.

88. Frank M. Snyder, Command and Control: Readings and Commentary (Cambridge, Mass: Harvard University Press, 1989), 14-17.

89. [V(INT)2], 86-89.

90. "B^2C^2", 13-14.

91. IVIS, 26-27.

92. "FM 100-5", (1992), 2-8.

93. US Army, FM 100-15 Corps Operations (Wash, DC: Department of the Army, 1989), 3-16.

94. "B^2C^2", 13.

95. "FM 100-5", (1992), 2-9.

96. Neky, 36-37.

97. Ibid, 2-10.

98. Neky, 41-42.

99. "B^2C^2", 2.

100. "FM 100-5", (edited version of 1992 draft), 2-16.

101. Ibid, 2-16.

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